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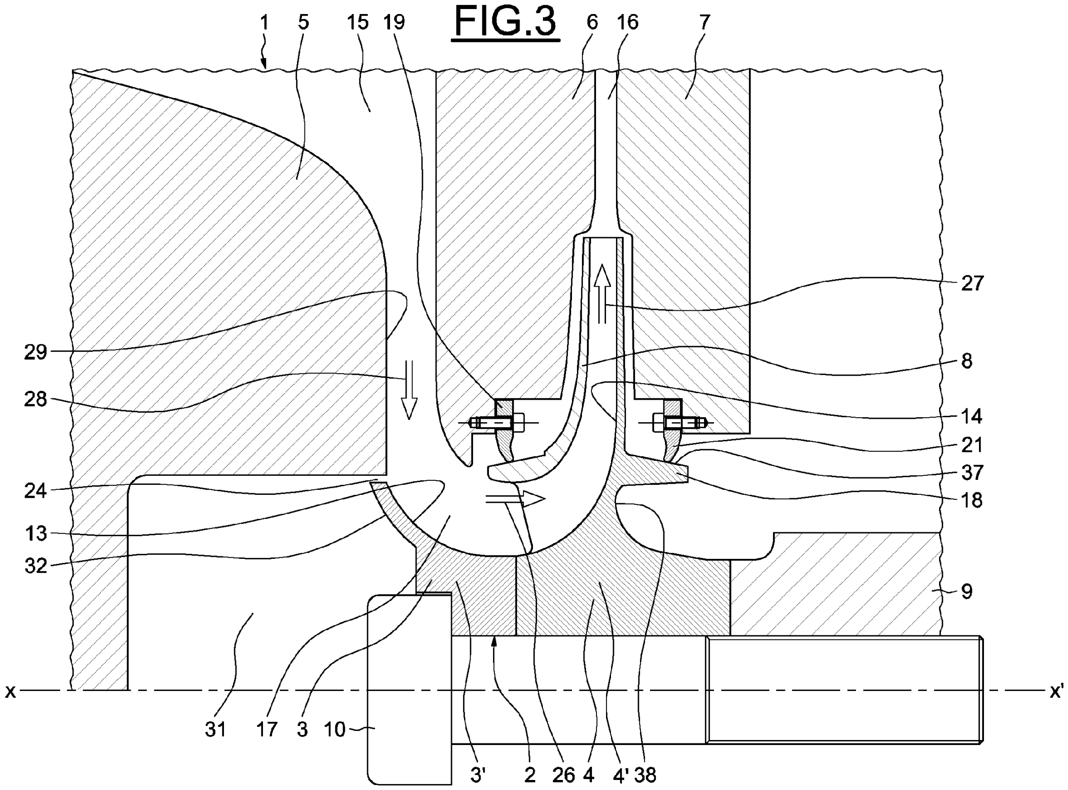
(54) Device for generating a dynamic axial thrust to balance the overall axial thrust of a radial rotating machine

(57) An impeller wheel assembly (2) for a radial rotating machine (1), comprises a bladed hub portion (4) of an impeller wheel, with a second radially outward facing, gas deflecting surface (14) having a curvature profile designed to deflect an axial gas flow into a radial centrifugal flow, and comprising a deflector portion (3) with a first radially outward facing, gas deflecting surface (13). The first radially outward facing surface (13) has a curvature profile designed to deflect a radial centripetal gas flow (28) into an axial gas flow (26).

FIG.3



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Description

[0001] The invention relates to radial rotating machines, such as centrifugal compressors or seal stage expanders.

[0002] Generally speaking, a radial rotating machine may be a rotating machine for processing a gas flow, the gas flow being forced to flow radially at least a long part of the flow part.

[0003] Centrifugal compressors are radial rotating machines: they comprise bladed impeller wheels which are designed to force the gas flow radially away from the axis of the rotating machine.

[0004] These impeller wheels are subjected to axial forces which may be of two types:

so-called static axial forces, which are generated by the difference in gas pressure between the upstream side and the downstream side of the wheel,

and so-called dynamic axial forces, which are a result of the momentum change imposed to the gases, flowing in axially into the impeller wheel, and coming out radially out of the wheel.

[0005] These axial forces are usually partly balanced by balance drum systems, and partly balanced by axial thrust bearings, for instance by magnetic axial bearings.

[0006] In balance drum systems, a balance drum part is assembled around the same shaft as the impeller wheel. The balance drum part comprises two radially extending surfaces, facing opposite axial directions, and subjected to different gas pressures.

[0007] These balance drum systems usually are tuned to compensate for static axial forces.

[0008] According to their design, balance drum systems can sometimes also compensate for part of the dynamic axial forces. The remainder of axial forces then has to be compensated with axial thrust bearings such as magnetic axial thrust bearings.

[0009] Depending on the maximum axial forces that the thrust bearing can withstand, and depending on the proportion of axial forces not compensated by the balance drum, the gas throughput of the machine has to be limited, to a value lower than the maximum throughput imposed by the other parameters of the radial rotating machine.

[0010] The invention aims at proposing an impeller wheel system which ensures a better axial force compensation, thus making it possible to use lighter balance drum systems and making it possible to reduce the axial bulk of the axial thrust bearings.

[0011] According to the invention, an impeller wheel assembly for a radial rotating machine, comprises a bladed hub portion of an impeller wheel, with a second radially outward facing, gas deflecting surface having a curvature profile designed to deflect an axial gas flow into a radial centrifugal flow, and comprising a deflector portion with a first radially outward facing, gas deflecting surface. The first radially outward facing surface has a curvature profile designed to deflect a radial centripetal gas flow into an axial gas flow.

[0012] In the radial centripetal flow and the radial centrifugal flow, a gas speed component may have an angle comprised between 70° and 90° with the axis of the impeller wheel. In the axial gas flow, a gas speed component may have an angle comprised between 0° and 10° with the axis of the impeller wheel. The radial rotating machine is a rotating machine for processing a gas flow, in which the gas flow occurs radially at least along part of the flow path. The radial rotating machine may be for instance a centrifugal compressor or a single stage expander. The first radially outward facing surface of the deflector portion may be a surface diverging toward a first axial end of the deflector portion distant from the hub portion, so as to reach or come tangent to a radial plane. The first radially outward facing surface of the deflector portion may be a surface converging so as to come tangent, toward a second axial end next to the hub portion, toward the second radially outward facing surface of the hub portion.

[0013] The radius of the first outward facing surface-that is, the distance to a rotation axis of the impeller wheel assembly-is less next to the hub portion, than the radius of the surface at its end opposite to the hub portion. Preferably, the radius of the first outward facing surface is minimum next to the hub portion. The first outward facing surface may, when following the surface in a direction toward the hub portion, converge first, than slightly diverge in the vicinity of the hub portion.

[0014] In a preferred embodiment, each of the first and the second outward facing surface is a surface defined respectively by a first and a second radial section curve which is concave, with a constant curvature radius or with a continuously varying curvature radius. The bladed hub portion and the deflector portion may belong to a same single piece.

[0015] Alternatively, the impeller wheel assembly may be made of an impeller hub part and of a deflector part, abutting axially onto each other so as to place their radially outward facing surfaces flush with one another. The impeller wheel assembly may comprise two parts, or more than two parts.

[0016] The deflector portion may comprise a radially inward facing surface continuously radially diverging in a direction away from the hub portion, along at least half of the axial length of the deflector portion.

[0017] Advantageously, the radial thickness of the deflector portion is maximum next to the hub portion. Thickness means here the material thickness of the part, excluding radial sizes of hollow regions. The maximum thickness of the deflector portion may be as least three times the minimum radial thickness of the deflector portion.

[0018] The invention also relates to a rotor assembly for a radial rotating machine, comprising a rotor shaft, an impeller wheel assembly as described above, and a shroud, assembled around the hub portion so as to trap an axial flow coming from the deflector region and forcing it along the second outward facing surface. The impeller wheel assembly and the shroud are assembled to the shaft so as to make the hub portion, the deflector portion, and the shroud rotate together. The shroud inner surface, or the second outward facing surface, or both, may be bladed surfaces.

[0019] The impeller wheel assembly may be assembled in axial overhang to the shaft, and the deflector portion is on the axial side opposite to the shaft.

[0020] The rotor assembly may comprise a balance drum assembled to the shaft, which is a separate part from the impeller wheel assembly.

[0021] The rotor assembly may comprise a balance drum integrated to the bladed hub. The blade hub portion may for instance comprise an annular sealing protrusion extending axially from the hub portion on the side of the wheel opposite to the deflector portion, the annular sealing protrusion facing a seal assembled to a stator portion.

[0022] The deflector portion may comprise a radially inward facing surface diverging radially in an axial direction away from the hub portion, and which is placed so as to be subjected to a same gas pressure as the gas pressure exerted on the first outward facing surface when the rotor assembly is in use.

[0023] In another embodiment, the deflector portion may face a seal system along a line which separates an area comprising the first outward facing surface from an area comprising a radially inward facing surface. The inner facing surface is then subjected to a different gas pressure from the gas pressure exerted onto the outer facing surface when the rotor is in use.

[0024] The radial width of the first outward facing surface is advantageously at least 0.8 times, and preferably 0.95 times the radial width of the radial inlet aperture between the second outward facing surface and the shroud.

[0025] The deflector portion and the hub portion may each comprise respectively a first radial surface and a second radial surface, facing respectively a first half of a first axial thrust bearing and a second half of a second axial thrust bearing.

[0026] The deflector portion may comprise a portion of surface extending radially, and which is placed so as to be subjected to a gas pressure different from the gas pressure exerted on the first outward facing surface.

[0027] In a preferred embodiment, the radial rotating machine comprises no other axial thrust bearings than the first axial thrust bearing and the second axial thrust bearing.

[0028] Some additional objects, advantages and other features of this invention shall be set forth in the description that follows.

[0029] A preferred but not limiting form of embodiment will now be described, with reference to the attached drawings, wherein :

- Figure 1 is a simplified section view of a portion of a rotating machine according to the invention;
- Figure 2 is a simplified section view of a portion of another embodiment of a rotating machine according to the invention,
- Figure 3 is a simplified section view of a portion of another embodiment of a rotating machine according to the invention, and
- Figure 4 is a simplified section view of a portion of yet another embodiment of a rotating machine according to the invention.

[0030] Figure 1 shows a portion of a centrifugal compressor 1 according to the invention. The compressor comprises a shaft 9 rotating around an axis X-X'. An impeller wheel assembly 2 is assembled in axial overhang to the shaft 9, so as to rotate around axis X-X'. Alternatively, the impeller wheel assembly may be assembled to the shaft by means of a Hirth join, of a conical assembly (by heat shrinking), cylindrical assembly (with a key to lock the assembly in rotation), or other known methods.

[0031] In the description, by "radial surface" one means a surface generated by a series of radial lines, that is perpendicular to the axis X-X' of the rotating machine.

[0032] By "axial surface" one means a surface generated by a series of axial lines, that is a portion of cylindrical surface with an axis parallel to the axis X-X'.

[0033] The impeller wheel assembly 2 comprises a bladed hub portion 4 and a deflector portion3, upstream of the bladed hub portion 4. On the embodiment represented on figure 1, deflector portion 3 is defined by a first deflector part 3', and bladed hub portion 4 is defined by a separate impeller wheel part 4', abutting axially onto the deflector part 3', so as to place the radially outward facing surfaces 13 and 14 flush with one another.

[0034] The bladed hub portion is covered by a shroud 8, so as to define a gas channel so designed as to deflect an axial gas flow 26 into a radial centrifugal flow 27.

[0035] The deflector portion 3 is placed upstream from the bladed hub portion 4, and has a first radially outward facing surface 13 which comes flush with a second radially outward facing surface 14 of the bladed hub portion 4.

[0036] The second outward facing surface 14, together with the inner face of the shroud 8, defines a gas guiding channel which is able to deflect the axial gas flow 26 into a centrifugal radial flow 27.

[0037] The surfaces defining the gas channel can be obtained by rotating around the axis X-X', the section lines of the impeller wheel, and of the shroud, visible on figure 1.

[0038] In other embodiments, the surface defining the inside of the channel may not be a surface of revolution, but may be obtained by a periodical rotation of a surface portion.

[0039] The deflector part 3 comprises an inwardly facing surface 32 extending both axially and radially, and radially diverging away from the hub portion 4. "Radially diverging" means here, the distance of this inwardly facing surface 32 increases as one moves along the surface axially away from the hub portion 4.

[0040] The impeller wheel assembly 2 is surrounded by stator parts such as an inlet cover 5, a diaphragm 6 and a diffuser wall 7.

[0041] The first radially outer facing surface 13, together with a partly radial surface of the diaphragm 6 and an opposite radial surface 29 of the inlet cover 5, defines an inlet channel 15 designed to deviate a radial centripetal flow 28 into an axial gas flow 26.

[0042] An axial interval between diaphragm 6 and diffuser wall 7 defines a diffuser channel 16 receiving a radial centrifugal flow 27 coming out of the impeller wheel portion 4.

[0043] An impeller eye seal 19 is assembled to the diaphragm 6. Seal 19 contacts the shroud 8 so as to avoid leakage of the incoming gas flow 28 directly towards the diffuser channel 16 without traversing the gas channel between the shroud and the bladed hub portion 4.

[0044] The deflector portion 3 is so designed that the first outward facing surface 13 comprises most of the deflecting surface necessary - on the radially inner side of the gas inlet channel 15 - in order to transform the radial centripetal flow 28 into an axial flow 26.

[0045] In this way, the deflector portion 3 is subjected to an axial force resulting from the total momentum change of the gas occurring before the gas penetrates into the bladed hub portion 4, into the channel defined between bladed hub portion 4 and the shroud 8.

[0046] In this way, the total axial forces exerted by the gases onto the deflector part 3 are opposite to the total axial forces exerted by the gases onto the bladed hub portion 4.

[0047] To achieve this, a preferred geometry is when inlet cover 5 extends up to the deflector portion 13, by a central surface portion 29 which is a portion of radial plane.

[0048] The first radially outward facing surface 13 of the deflector portion 3 comes tangent to the radial plane defined by the central surface portion 29 of the inlet cover 5.

[0049] The outward facing surface 13 may not come exactly tangent to a radial plane, but should comprise an end surface region that makes an angle of no more than 10°, and preferably no more than 5°, from a radial plane.

[0050] In order to ensure sufficient deflection of the incoming gases, from the radial centripetal direction into an axial direction, the first outward facing surface 13 should also extend radially far enough from the axis X-X' of the rotating machine.

[0051] As shown on figure 2, a maximum radius R1 of the surface 13 - R1 counted at a maximum distance from the axis X-X' to a point of the outward surface 13 - should be almost as large as an internal radius R2 of the shroud 8 -R2 counted at a minimum distance between an inner face of the shroud 8 and the axis X-X'-.

[0052] Typically R1 should be at least 0.8 times, and preferably 0.95 times the value of R2. Of course, R2 remains larger than R1 in order to be able to assemble the shroud 8 by moving it axially around the deflector portion 3.

[0053] Together, the first outward facing surface 13 and the second outward facing surface 14, form a total guiding deflecting surface for the gases traversing the rotating machine. This total guiding surface is preferably defined by a concave radial section curve, preferably with a continuously varying radius of curvature, so as to avoid generating unwanted turbulent flows.

[0054] A circle 30 of minimum radius on this total guiding surface, corresponding to the points of minimum distance of the surface on the axis X-X' is shown in section on figure 1. This circle 30 can belong either to the first outward facing surface 13 or to the second outward facing surface 14.

[0055] In the illustrated embodiment of figure 1, the minimum radius of the surface is reached on the first outward facing surface 13.

[0056] The minimum radius circle 30, when belonging to a deflector part 3', is usually located on the deflector part side closer to the bladed hub portion 4, on the first axial half, and preferably on the first axial third, of the deflector part's length.

[0057] In order to limit balancing problems, and to limit the total weight of the impeller wheel assembly, the radial thickness of the deflector portion 3 is limited to a thickness necessary to withstand the incoming gas pressure, except in a a region axially close to the bladed hub portion, where the deflector portion has a thickness necessary to assemble the deflector portion around the shaft 9, or around fixing means 10 holding the deflector portion assembled to the shaft.

[0058] Owing to this fact, the maximum radial thickness e1 (illustrated on figure 2) is found on a first half axial length, and preferably on a first third of axial length, of the deflector portion 3, closest to the bladed hub portion 4.

[0059] On at least a third of axial length of the deflector portion 3 placed axially opposite to the bladed hub portion 4, a radial thickness e2 of the deflector portion 3 is preferably limited to less than a third of the maximum radial thickness e1 of the deflector portion.

[0060] This contributes to ensuring a light weight of the impeller wheel assembly, which may be assembled in axial overhang to the shaft 9 as illustrated on figures 1 to 4.

[0061] The impeller wheel assembly could also be assembled around a shaft, for instance in a multistage rotating machine. In a multistage rotating machine, several impeller wheels assemblies according to the invention can be present in successive stages.

[0062] As can be seen on figure 1, the rotating machine 1 comprises a downstream pressure seal 23, which can be for instance a labyrinth seal, and which is placed between the diffuser wall 7 and the shaft 9 so as to limit gas leakage from the diffuser channel 16.

[0063] In the embodiment illustrated on figure 1, the radial rotating machine 1 comprises an upstream balance drum seal 20 placed so as to avoid gas leakage between the inlet channel 15 and a volume 31. The volume 31 is limited at least partially by radially inward facing surface 32 of the deflector portion 3, and by an inner, axially extending, surface 33 of the inlet cover 5.

[0064] The radial thickness e2 of the deflector part 3, which is the thickness separating the inward facing surface 32 and the first outward facing surface 13, may be of constant value, corresponding to the thickness necessary for the deflector portion 3 to withstand the incoming gas pressure.

[0065] Thanks to the upstream balance drum seal 20, a different gas pressure can be established on the first outward facing surface 13 and on the radially inward facing surface 32.

[0066] This difference in gas pressure can generate a balance drum effect, which can be tuned to compensate for of at least part of the static axial forces exerted on the impeller wheel assembly 2.

[0067] Figure 2 illustrates another embodiment of a radial rotating machine according to the invention.

[0068] Similar elements to figure 1 can be found on figure 2, which are designated by same references.

[0069] On the embodiment of figure 2, no upstream balance drum seal is placed between the inlet cover 5 and the deflector portion 3.

[0070] A pressured balancing gap 24 is present on the contrary between the inlet cover 5 and the deflector portion 4, so that the gas pressure that can be measured close to the first outward facing surface 13, is the same as the gas pressure that can be measured close to the radially inward facing surface 32 of the deflector portion 3.

[0071] In this embodiment, a balance drum part 25 is integrated to the shaft.

[0072] On figure 2, this balance drum part is one piece with the shaft 9 but it could be also assembled around the shaft 9.

[0073] The balance drum part 25 is designed so as to come radially close to a portion of the diffuser wall 7, on which a downstream balance drum seal 22 is assembled. The balance drum seal 22 is configured to avoid gas leakage between a volume 34, defined on a downstream side of the impeller wheel assembly 2 but upstream from at least a radially extending surface portion 35 of the balance drum part 25, and between a volume 36 defined downstream of the diffuser wall 7. Different gas pressures can be established in volumes 34 and 36, thus ensuring a balance drum effect compensating for at least part of the axial forces to which the impeller wheel assembly 2 is subjected.

[0074] In figure 2, deflector portion 3 and bladed hub portion 4 are one piece.

[0075] Figure 3 illustrates yet another embodiment of a radial rotating machine according to the invention. Similar elements to previous figures can be found, which are designated by same references.

[0076] In the embodiment illustrated on figure 3, a pressure balancing gap 24 ensures that more or less a same gas pressure is established in inlet channel 15, close to the first outward facing surface 13, and in volume 31 close to the radially inward facing surface 32 of the deflector portion 3.

[0077] The radial rotating machine of figure 3 comprises a downstream balance drum seal 21, assembled to the diffuser wall 7 so as to come into contact with an axially extending surface 37 belonging to an axial protrusion 18 of the bladed hub portion 4.

[0078] The protrusion 18 is a more or less an annular axially extending protrusion, extending axially to the downstream side of the bladed hub portion 4, so as to define an axially extending surface 37 radially close to the diffuser wall 7.

[0079] Seal 21 makes it possible to get a different gas pressure within the gas channel along the second outward facing surface 14, from the pressure on an at least partly radially extending surface 38 surrounded by protrusion 18. This pressure difference generates axial forces which can be tuned to compensate for at least part of the static axial load exerted on the impeller wheel assembly 2.

[0080] Figure 4 shows yet another embodiment of a radial rotating machine according to the invention. Similar elements to previous figures can be found, which are designated by same references. In the embodiment of figure 4, the deflector portion 3 comprises a radial surface 39 and a first half axial bearing 11 which faces the radial surface 39. Radial surface 39 is surrounded by the radially inward facing surface 32, so that the half axial bearing 11 can be at least partially axially inserted at the centre of a volume limited by the inward facing surface 32 of the deflector portion.

[0081] In other words, there is an axial overlap between the half axial bearing 11 and the deflector portion 3.

[0082] This overlap reduces the overall length necessary for the radial rotating machine 1.

[0083] The radial rotating machine 1 of figure 4 also comprises a second half axial bearing 12, facing a radially extending surface 40 belonging to the bladed hub portion 4, and limiting the bladed hub portion 4 on its downstream axial side. The radial surface 40 is placed radially inward of annular sealing protrusion 18, so that the second half axial bearing 12 can be inserted axially within a space limited radially by axial protrusion 18. The axial overlap between the second half axial bearing and the bladed hub portion also contributes to reducing the total axial length of the radial rotating machine.

[0084] The invention is not limited to the embodiments described and illustrated above, which are to be regarded as mere examples of a wider range of embodiments.

[0085] The impeller wheel assembly may be assembled around a shaft, instead of being assembled in axial hang to a shaft. It may be one piece or it may comprise two or more pieces abutting axially one into another. The balance drum function may be generated by a seal, assembled to a stator part and contacting the impeller wheel assembly, the seal either contacting the deflector portion or contacting the bladed hub portion. In another embodiment, the balance drum function may be generated by a seal contacting a part distinct from the impeller wheel assembly.

[0086] The first and the second half axial bearings facing two axially opposed radial surfaces of the impeller wheel assembly may be at the same radial distance from the axis X-X' of the rotating machine or may be placed at a slightly different radial distance.

[0087] When the impeller wheel assembly comprises two or more axially abutting parts, at least one separation between two of the parts is located axially close to a minimum radius location of the gas channel penetrating into the impeller wheel. The separation may not be located exactly at the axial position corresponding to the minimum radius.

[0088] With an impeller wheel assembly according to the invention, the remainder of axial forces which is to be compensated by axial first bearings is reduced. The size of the axial thrust bearing -which may be magnetic axial thrust bearings-, may then be reduced. The total length of the radial rotating machine may be quite compact, due to the fact that an axial overlap is possible between the axial thrust bearings and the parts ensuring the deflector function and/or the balance drum function.

[0089] Owing to the axial forces self balancing ability of the impeller wheel assembly, higher gas throughputs can be allowed through the rotating machine. Such high throughputs sometimes occur in transient regimes, which formally implied designing much bulkier thrust bearings.

[0090] Such high throughputs may also be of interest in order to let a large quantity of gas go through the machine even without ensuring the basic function of the machine.

[0091] The impeller wheel assembly according to the invention does enable to construct more compact radial rotating machines with wider functioning ranges, especially as a gas throughput is concerned.

Claims

1. Impeller wheel assembly (2) for a radial rotating machine (1), comprising a bladed hub portion (4) of an impeller wheel, with a second radially outward facing, gas deflecting surface (14) having a curvature profile designed to deflect an axial gas flow into a radial centrifugal flow, and comprising a deflector portion (3) with a first radially outward facing, gas deflecting surface (13), **characterized in that** the first radially outward facing surface (13) has a curvature profile designed to deflect a radial centripetal gas flow (28) into an axial gas flow (26).

2. Impeller wheel assembly according to claim 1, in which the bladed hub portion (4) and the deflector portion (3) belong to a same single piece.

3. Impeller wheel assembly according to claim 1, made of an impeller hub part (4') and a of a deflector part (3'), abutting axially onto each other so as to place their radially outward facing surfaces flush with one another.

4. Impeller wheel assembly according to any of preceding claims, in which the deflector portion (3) comprises a radially inward facing surface (32) continuously radially diverging in a direction away from the hub portion (4), along at least half of the axial length of the deflector portion (3).

5. impeller wheel assembly according to any of preceding claims, in which the radial thickness (e1) of the deflector portion is maximum next to the hub portion (4).

6. Rotor assembly for a radial rotating machine, comprising a rotor shaft (9), an impeller wheel assembly (2) according to any of the preceding claims, and a shroud (8), assembled around the hub portion (4) so as to trap an axial gas flow coming from the deflector portion (3) and forcing it along the second outward facing surface (14).

7. Rotor assembly according to claim 6, in which the impeller wheel assembly (2) is assembled in axial overhang to the shaft (9), and the deflector portion (3) is on the axial side opposite to the shaft (9).

8. Rotor assembly according to claims 6 or 7, comprising a balance drum (25) assembled to the shaft (9), which is a separate part from the impeller wheel assembly (2).

9. Rotor assembly according to claim 6, comprising an impeller wheel assembly (2) according to claim 3, and comprising a balance drum (18) integrated to the bladed hub.

10. Rotor assembly according to any of claims 6 to 9, in which the deflector portion (3) comprises a radially inward facing surface (32) diverging radially in an axial direction away from the hub portion (4), and which is placed so as to be subjected to a same gas pressure as the gas pressure exerted on the first outward facing (13) surface when the rotor assembly is in use.

11. Rotor assembly according to any of claims 6 to 9, in which the deflector portion faces a seal system (20) along a line which separates an area comprising the first outward facing surface (13) from an area comprising a radially inward facing surface (32) of the deflector portion.

12. Rotor assembly according to any of claims 6 to 11,

in which the radial width (R1) of the first outward facing surface (13) is at least 0.8 times, and preferably 0.95 times the radial width (R2) of the radial inlet aperture between the first outward facing surface (13) and the shroud (8).

13. Radial rotating machine (1) comprising a rotor assembly according to any of claims 6 to 11, in which the deflector portion (3) and the hub portion (4) each comprise respectively a first radial surface (39) and a second radial surface (40), facing respectively a first half (11) of a first axial thrust bearing and a second half (12) of a second axial thrust bearing.

14. Radial rotating machine according to claim 13, in which the deflector portion (3) comprises a portion of surface (32) extending radially, and which is placed so as to be subjected to a gas pressure different from the gas pressure exerted on the first outward facing surface (13).

15. Radial rotating machine according to claims 13 or 14, with no other axial thrust bearings than the first axial thrust bearing and the second axial thrust bearing.

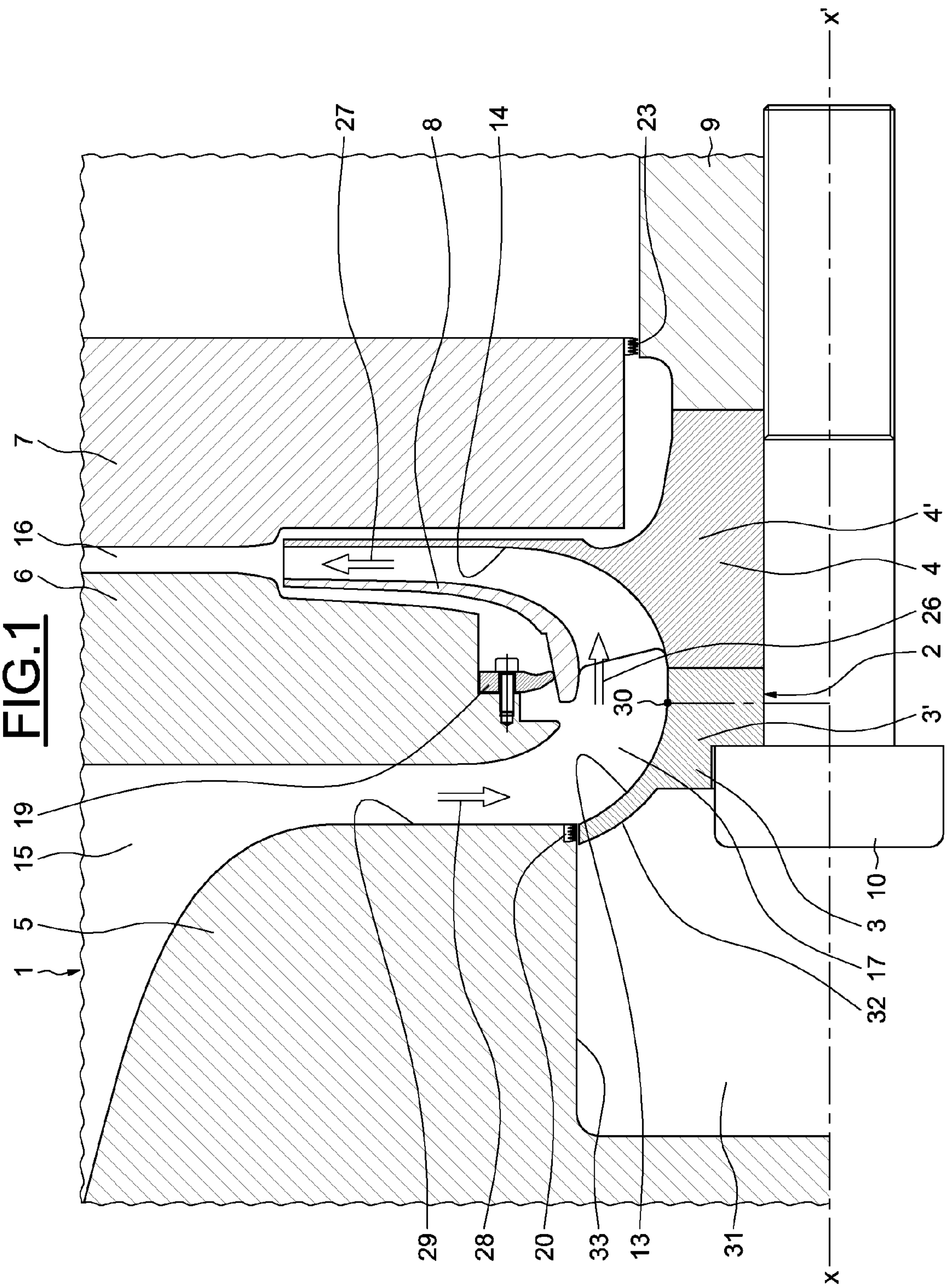

FIG.1

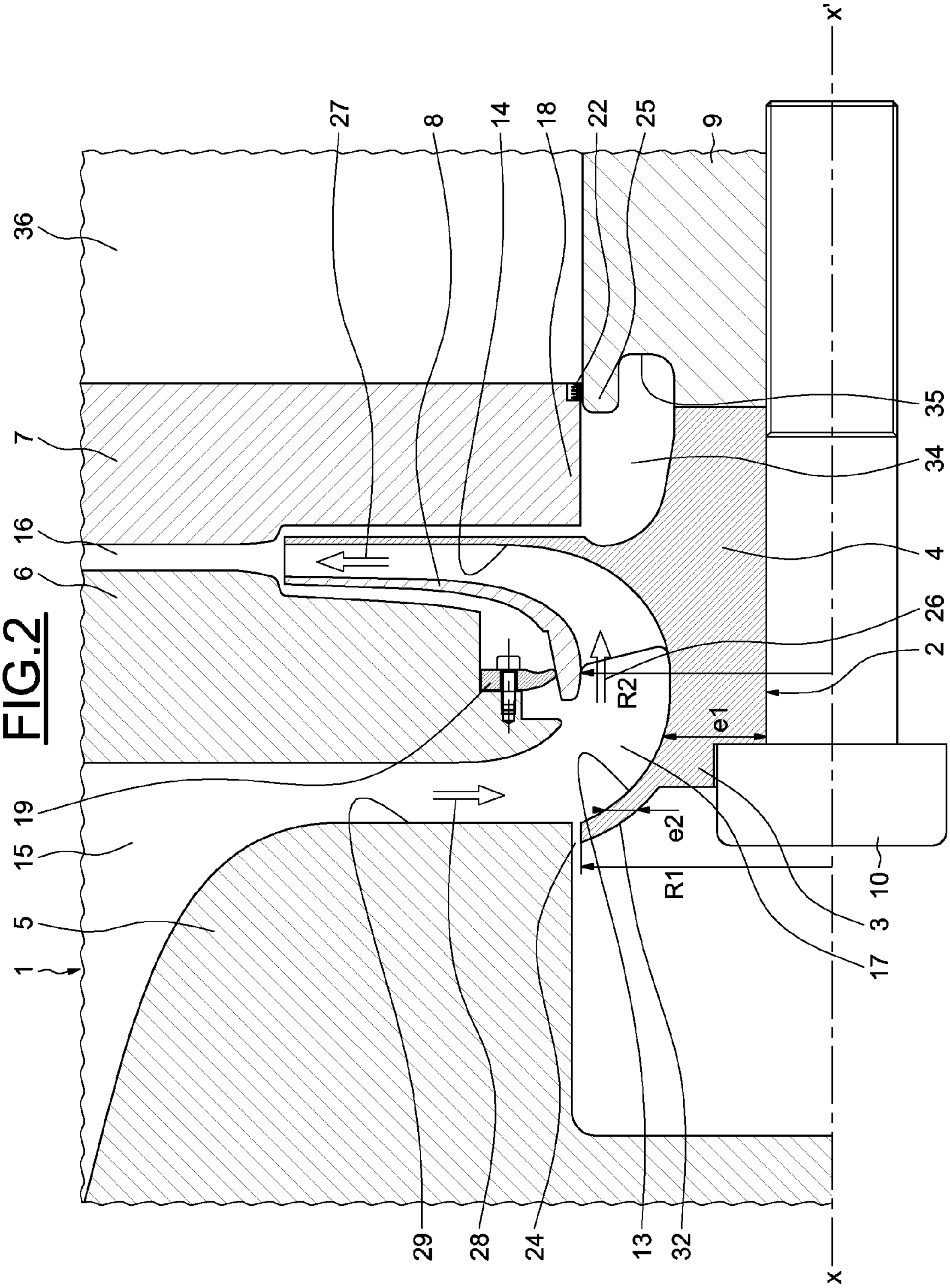
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FIG.2

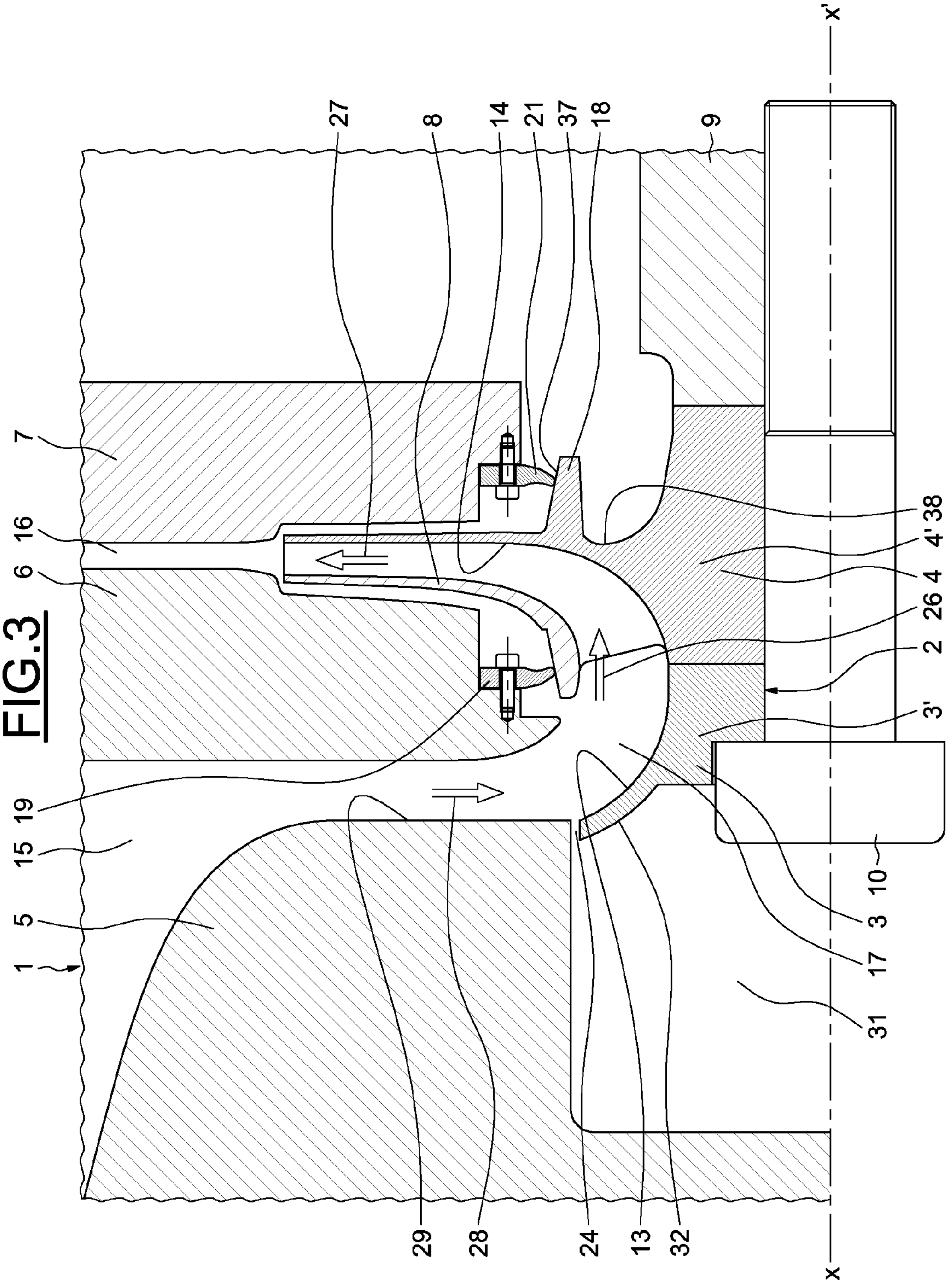

FIG.3

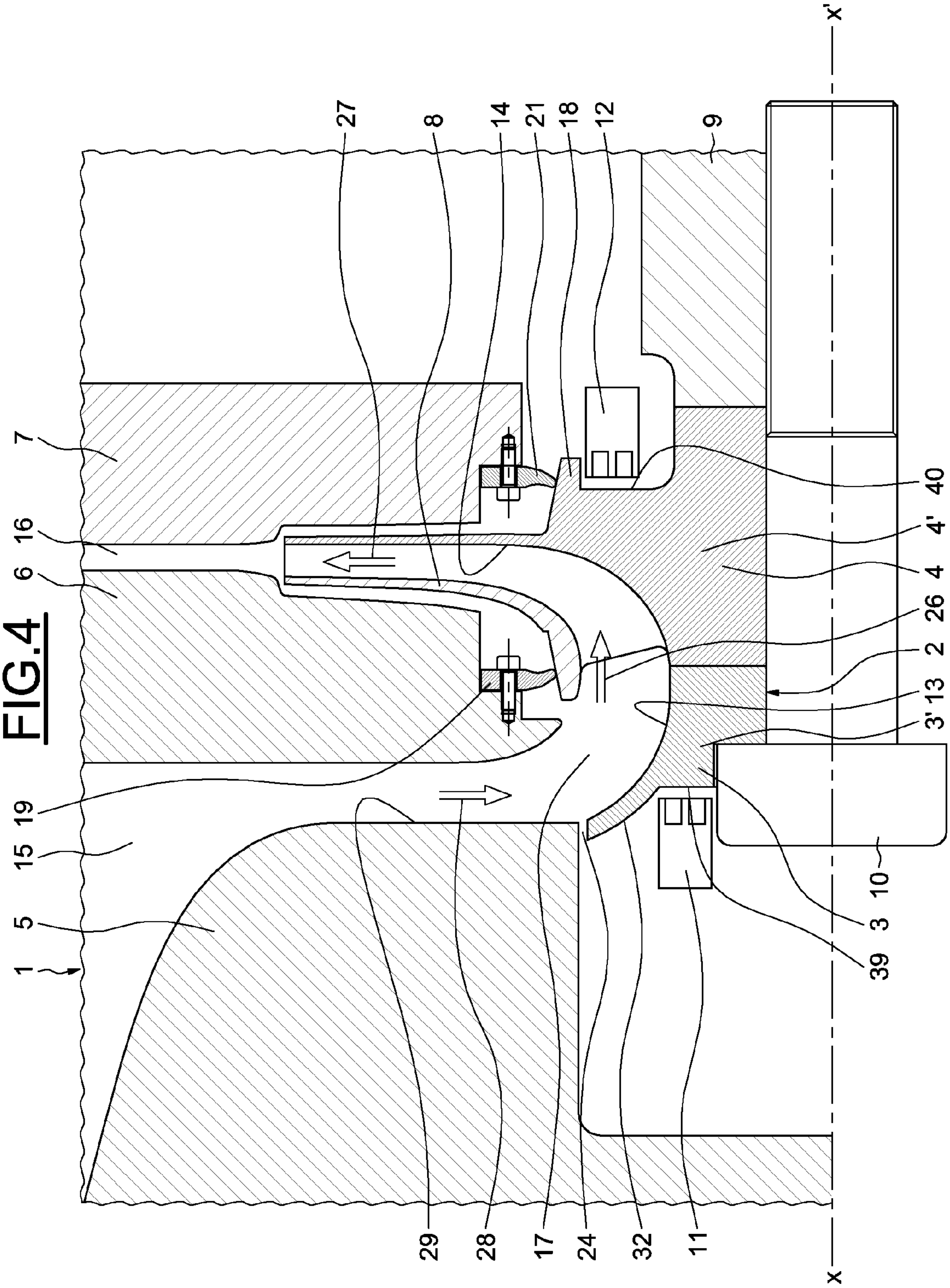

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FIG.4

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 12 30 6676

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 04 332 B (MASCHF AUGSBURG NUERNBERG AG) 14 March 1957 (1957-03-14) * the whole document * * claim 1 * * figure 1 * -----	1,3,6	INV. F04D29/28 F04D29/44 F04D29/051
X	US 2011/262284 A1 (GUERNARD DENIS GUILLAUME JEAN [IT]) 27 October 2011 (2011-10-27) * the whole document * * figures 2,3 * -----	1,2,6	

TECHNICAL FIELDS SEARCHED (IPC)
F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	12 June 2013	Ingelbrecht, Peter

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 30 6676

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12-06-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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